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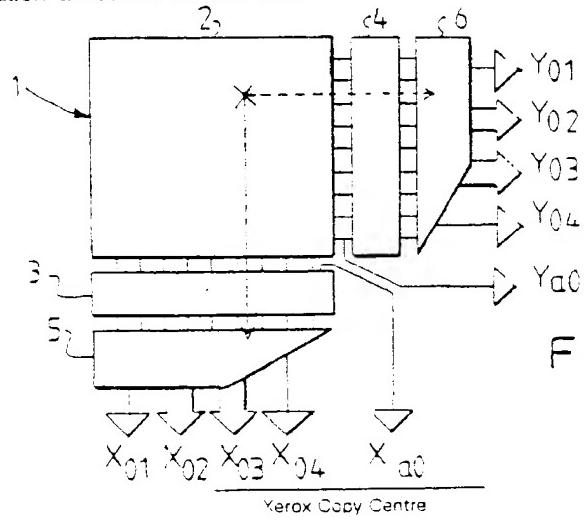
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(13) Image portion determination of a solid-state imaging device.

(14) A radiation transducing device (1) comprising an array (2) of pixel elements (8) in which a pixel element is only read out when the radiation that is incident on that pixel element exceeds a predetermined threshold value.

Encoding circuits (5, 6), connected to comparators (3, 4) and radiation measuring element (21) provide a digital representation ( $x_{01}, x_{02}, x_{03}, x_{04}, x_{05}, y_{01}, y_{02}, y_{03}, y_{04}, y_{05}$ ) of the portion of the pixel array, whose incident radiation amount exceeds said threshold value.



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### Radiation transducing device

The present invention relates to a radiation transducing device.

Radiation transducing devices from the prior art, e.g. EP-A-015714 consist of a matrix of pixel elements of which each pixel element is scanned sequentially, e.g. for the scanning of pictures in a television or video apparatus.

As further prior to the applicant EP-A-0260858 and the article: "The VLSI design of a two dimensional image processing array" of D. Panagiotopoulos et al., published in Microprocessing and Microprogramming, vol. 14, no. 3/4, October/November 1984, is known.

At scanning a picture area in which only on one or some locations radiation is to be detected, those transducing devices of the prior art produce an enormous amount of signals of which the information content has substantially no value at all.

It is an object of the present invention to improve upon the prior art and to provide a new radiation transducing device.

The present invention provides a transducing device occurring to claim 1.

The field of application of the present invention relates to fast consecutive recording of collisions of elementary particles in experiments at high energy storage rings, e.g. at CERN, as well as the continuous watching of ground environment, e.g. for detecting flashings of lightning accoring above the ground.

A preferred embodiment is provided with means for detecting two or more so-called events separately.

Further advantages, features and details will be clarified in view of a preferred embodiment of the radiation transducing device according to the present invention, described with reference to a drawing, in which show:

fig. 1 a diagram of a preferred embodiment of a radiation transducing device according to the present invention;

fig. 2 a diagram of an embodiment of a radiation sensitive element of the diagram of fig. 1;

fig. 3 a diagram of a comparator element of fig. 1;

fig. 4 a diagram of the connection of the source followers of fig. 2;

fig. 5 a diagram of an embodiment of the encoding elements of fig. 1;

fig. 6 a diagram of a second preferred embodiment of a radiation transducing device according to the present invention; and

fig. 7 a diagram of detail VII of fig. 6.

A preferred embodiment of a radiation transducing device 1 (fig. 1) comprises a matrix 2 of

arrays of radiation sensitive (pixel) elements, in which both in lying (x) and standing (y) direction a comparator element is connected to each row of pixel elements which are connected in parallel to each other (similar as shown in fig. 4), as is diagrammatically set forth by blocks 3, 4 resp.. To comparator blocks 3, 4 resp. encoding blocks 5, 6 resp. are connected, of which output  $x_{a1}, x_{a2}, x_{a3}, x_{a4}, y_{a1}, y_{a2}, y_{a3}, y_{a4}$  resp. are derivable, as will be clarified in the following description. Outputs  $x_{a0}, y_{a0}$  resp. are directly derivable from the outputs of the matrix or pixel elements.

A preferred embodiment of the pixel element 7 (fig. 2) of the matrix 2 comprises a radiation sensitive element in the form of a photo sensitive diode 8 on which radiation R is incident, which is connected through an inverting amplifier 9 having FET'S 10, 11 resp. for producing a signal to comparator blocks 3, 4 resp. said FET'S connected as source followers. A capacitor 30 and a electronic reset switch 31 are connected over the inverting amplifier 9.

Outputs  $x_{ac}$  and  $y_{ar}$  produce (in a not shown way), similar to the way shown in fig. 4 for each column, row resp. an output signal  $x_{ac}, y_{ac}$  resp., which form a common output signal for each column, row resp. of the matrix 2. For the purpose of deriving such a common output signal the source followers 10, 10', 10'' etc., the source follows 11, 11', 11'' etc. resp. of each pixel element are connected in parallel for each column, row resp..

A comparator element, e.g. a NCR-flipflop 12, is connected to the output  $x_{ac}$  (and  $y_{ar}$ ) of each row (and column) of the pixel matrix. A threshold value for switching dependent on the amount of radiation incident on a photosensitive diode 8 is determined by the dc bias level of the input  $x_{ac}$  relative to the negative supply voltage. This dc bias level can be set e.g. by means of the setting of the inverting amplifiers 9. The input 15 of the NOR-flipflop 12 forms a reset terminal, which may initialize a new image recording. The output 16 has a logic "0" or "1" value, dependent on the fact whether or not the amount of radiation incident to the corresponding column (or row) of the matrix is higher than a predetermined (and preset) value.

The (analog) output  $x_{a0}$  (fig. 4) (and  $y_{a0}$  in a corresponding row) is formed, because of the fact that source followers 32, 32', 32'' etc. are connected in parallel and in series to a load or measuring element 21. When radiation is incident to more than one row or column of the radiation sensitive elements 8, the voltage over the load 21 is determined by the largest amount of radiation incident to a "hit" element. The load 21 will in most

cases be a resistor, but may also be a switchable capacitor.

The encoding block 5 and 6, preferably of similar structure, may be realized by means of a multiplexer. In this way a data reduction is achieved e.g. for a 100 x 100 image transducing element of thus 10,000 pixel elements of e.g. 100 x 100  $\mu\text{m}^2$  each, of 10,000 to 100 data for each image period. The image period can decrease from 1 msec to 10  $\mu\text{sec}$  or the energy consumation may decrease by a factor of 100 in a corresponding way. Further the number of clocking member and power supplies for controlling the image transducing element of the present invention is limited relative to known CCD transducing devices.

Preferably a combinational logic circuit is used as coding block 5, 6 resp., of which an embodiment (of which purpose of simplicity only 3 bits are shown, is disclosed in fig. 5; the image period can be reduced to e.g. 100 nsec by means of this embodiment, or the energy consumption can be reduced to less than 1 mW. The circuit of fig. 5 comprises NOR-circuits 21, inverters 22 and OR-gates 23. The circuit is to be seen as built of base block A and B+. The shown embodiment accomplishes the encoding for eight inputs ( $i_0-i_7$ ) connected to outputs 16 of the comparator elements. By means of block A and B a circuit for a number of inputs larger than eight can be built in a simple way.

The outputs of the circuits shown in fig. 5 produce in a consecutive way from the top down:

- Y/N: whether or not an amount of radiation above a preset threshold value to the radiation transducing device is present;
- MSB the most significant bit value of the row or column of the pixel element having the highest rank number of the pixel element to which radiation was incident;
- 2SB the centre bit value of a row or column having the highest rank number to which radiation was incident; and
- LSB the least significant bit value of a row or column having the highest rank number of the pixel element to which radiation was incident.

When two encoding circuits of fig. 5, in the preferred embodiment of the radiation transducing device (both to x and y side) are disposed, while inputs  $i_0-i_7$  are supplied in inverted sequence to a second encoding circuit, the following may be determined from a comparison of bit values at the outputs, because one encoding circuit detects the lowest and the other the highest activated row (or column) value:

- the same result means that only pixelelements of one row, column resp. are activated by radiation; or
- an unequal result defines the borders of an area in which at least two rows (or columns) of six-

elements are activated.

Preferably the output of the encoding blocks 5, 6 resp. contain the following information:

- $x_{c1}$  ( $y_{c1}$ ) a bit which defines whether or not a pixel element in a column (row) is activated (Y/N of fig. 5);
- $x_{c2}$  ( $y_{c2}$ ) a digital number defining the highest column number (row number) of a column (row) of a pixel element to which radiation is incident;
- $x_{c3}$  ( $y_{c3}$ ): a digital number which defines the lowest column number (row number) of a column (row) of a pixel element to which radiation is incident; and
- $x_{c4}$  ( $y_{c4}$ ): a bit value which defines whether or now the highest and lowest column number (row number) is equal; this bit value  $x_{c4}$  ( $y_{c4}$ ) is derived in a simple way through a combination allogic circuit which compares the outputs of two logic circuits of fig. 5.

A first radiation transducing device to be realized is completely monolithically in integrated form in a semiconductor substrate and comprises 32 x 32 pixel element, of which the expectation is that a 50% filling degree of the surface is available to radiation sensitive elements.

Other possible embodiments include the so-called flipchip structure, in which a separate diode chip is connected to a separate chip for the peripheral electronics, and the so-called SOI technique, in which electronics is situated at the back side relative to the incident radiation, separated by silicon oxide from the radiation sensitive elements.

Another preferred embodiment 31 (fig. 6) of the present invention comprises pixel elements 32, 32', 32'' etc. and encoding blocks 33, 34 resp. similar to those of fig. 1. Further a first pixel element 32 is externally provided with a carry-in signal  $C_{in}$  and provides a further carry signal C to a second pixel element 32' which in term provides a further carry signal C' and so on until the last pixel element 32'' which provides a carry-out signal  $C_{out}$  that may be used for a further integrated transducing device.

By means of a sample signal S (fig. 7) a signal value related to the radiation R it is transferred to a flipflop circuit 33 and by means of an additional clocksignal T to a output carry signal C. If a pixel element 32' did not detect radiation, a incoming carry signal C is passed as outgoing carry signal C' controlled by clock signal T. If however radiation above a threshold value was detected and incoming carry signal C has a zero value, than this means that this pixel element 32' is the first of all the pixel elements that has been "hit". By means of clocksignal T the flipflop 33 is reset during the second half period of this clocksignal.

By means of the carry signals C added by the sample signal S the transducing device 31 is capable of reading out the row and column numbers

of all the pixel elements hit by radiation and also the analog signal values  $x_{30}$  and  $y_{30}$  thereof, without much loss of speed.

Further modification and variations of the present invention are possible within the scope of the present invention, defined by the annexed claims.

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**Claims**

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1. A transducing device for transducing radiation, comprising an array of elements sensitive for radiation, comparator elements connected to an array part of said elements, for comparing the amount of radiation received by a radiation sensitive element with a predetermined threshold value, an encoding element connected to said comparator element for producing a digital representation of the element on which radiation was incident and a measuring element connected to said radiation sensitive elements for determination of the amount of incident radiation to said corresponding element during a predetermined time period.

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2. A radiation transducing device, in which the array of radiation sensitive elements is a matrix, of e.g. 100 x 100 or 32 x 32 elements.

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3. A radiation transducing device of claim 2, in which the radiation sensitive elements of one row or column are commonly connected to a comparator element, for determination of the row or column number.

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4. A radiation transducing device of claim 3, in which two or more signals of two or more rows or columns of radiation sensitive elements are supplied to a common load for the determination of the maximum value of said signals.

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5. A radiation transducing device according to one of the preceding claims, in which said encoding element is embodied as combinatorial logical circuit.

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6. A radiation transducing device of claim 5, in which two combinational encoding elements are connected to the output of the comparator elements.

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7. A radiation transducing device of claim 1, in which means for providing a carry signal are provided between the pixel elements in said array.

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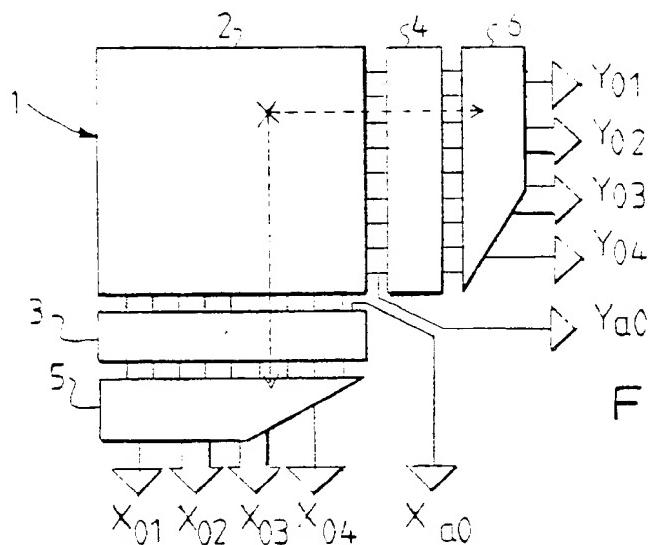


FIG.1

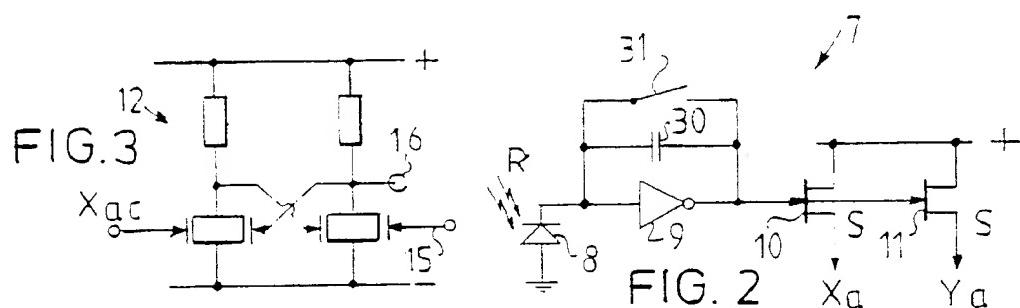


FIG. 3

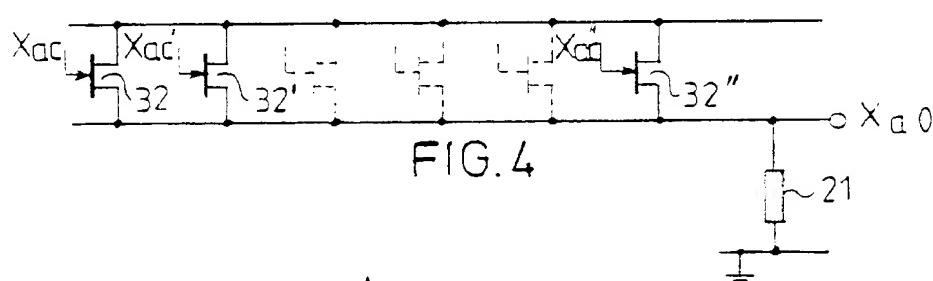


FIG. 4

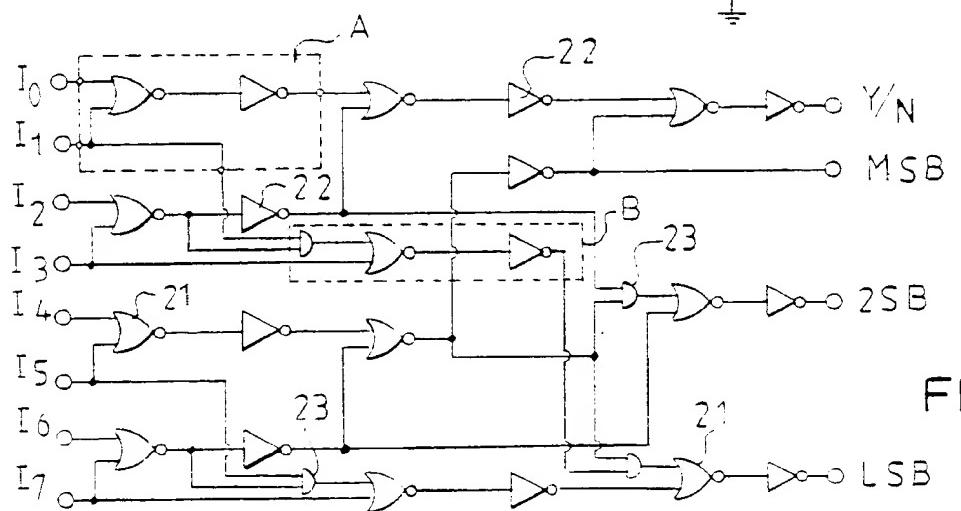


FIG. 5

FIG. 6

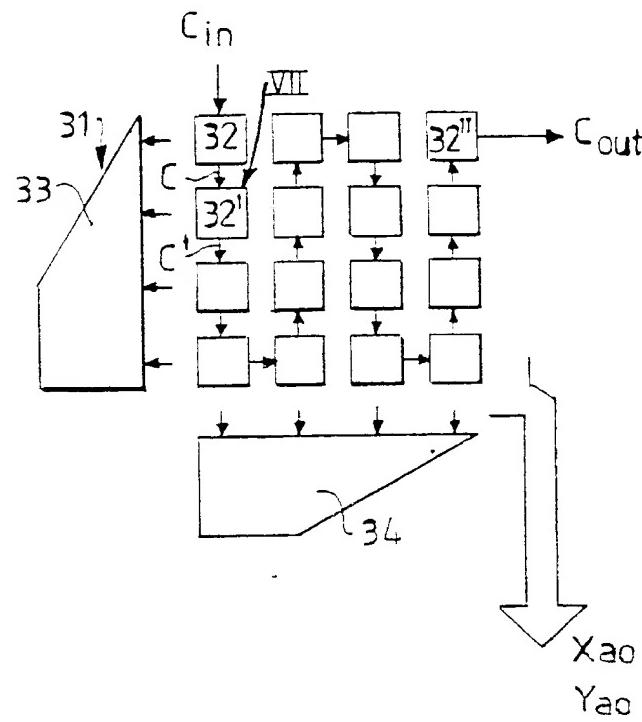
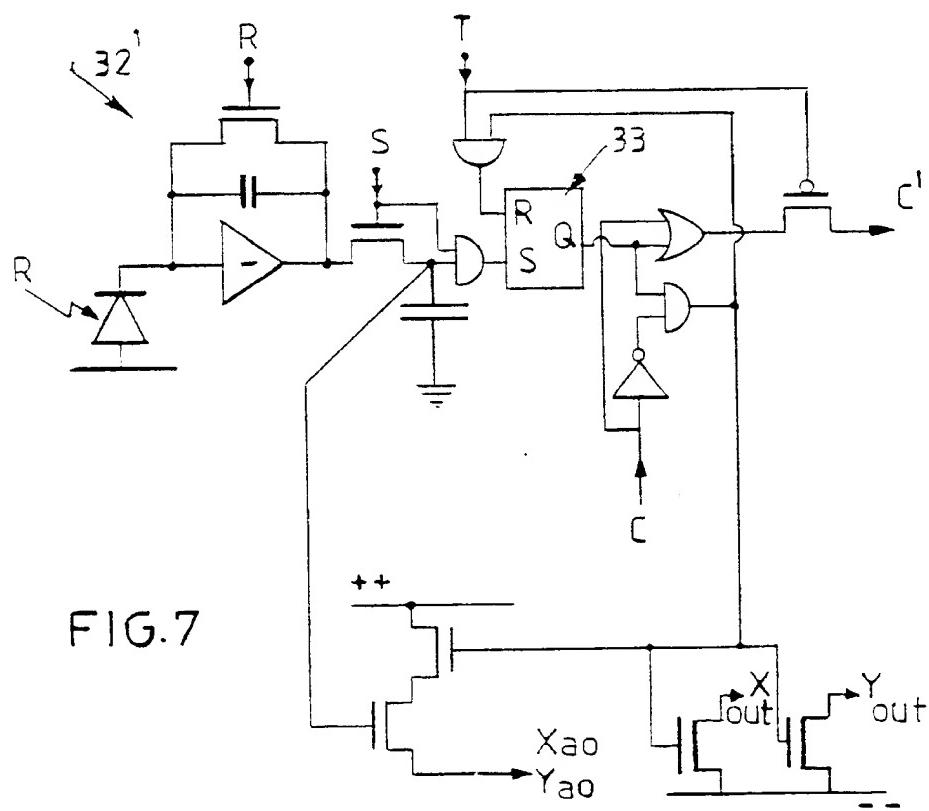


FIG. 7





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## EUROPEAN SEARCH REPORT

**Application Number**

EP 89 20 1347

## **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
X,D	EP-A-0 157 141 (PROGE) * Page 4, line 32 - page 7, line 7; page 8, line 22 - page 9, line 5 *	1,3,5	H 04 N 5/335
Y,P	---		
Y,P	WO-A-8 901 129 (B.V. OPTISCHE INDUSTRIE 'DE OUDE DELFT') * Page 4, line 19 - page 5, line 16; page 5, line 26 - page 7, line 24; page 9, lines 8-20 *	1,3,5	
A,P	---	4,6	
Y	WO-A-8 403 810 (FORCHHEIMER) * Page 2, line 11 - page 4, line 38 *	1,3,5	
A	---	6	
A,D	MICROPROCESSING AND MICROPROGRAMMING, vol. 14, no. 3/4, October/November 1984, pages 125-132; D. PANOGIOTOPoulos et al.: "The VLSI design of a two dimensional image processing array" * Page 125, left-hand column, line 24 - right-hand column, line 21; page 126, left-hand column, line 10 - right-hand column, line 23 *	1-3,5	
A,D	---		TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A,D	EP-A-0 260 858 (CANON K.K.) * Column 5, line 15 - column 7, line 9 *	1,4	H 04 N 5
A	---		
A	US-A-4 219 845 (GIBBONS et al.) * Column 1, lines 36-50 *	1,7	
	-----		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24-08-1989	DUHR R.H.J.E.

#### CATEGORY OF CITED DOCUMENTS

- X : particularly relevant if taken alone  
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 A : technological background  
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